Corporate taxation and firm-level investment in South Africa

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Abstract

This paper investigates the responsiveness of firm-level investment to corporate tax changes in South Africa over the period 1999 to 2012. The study exploits rare changes in corporate tax policy to assess the responsiveness of firm-level investment among Johannesburg Stock Exchange listed non-financial firms. Our estimation of a neoclassical investment model using GMM techniques shows that although changes in corporate tax policy reduced the tax-adjusted marginal cost of capital over time, the reductions did not translate into significant investments in fixed assets. We speculate that the well-documented financial frictions in the capital markets could explain the failure of neoclassical investment theory in South Africa. Our findings are similar to those in other developing countries and crucially suggest that investment policies should look beyond the use of corporate tax incentives.

Keywords: corporate taxation, capital investment, user cost of capital

JEL codes: E22; H32; C23

1 Introduction

No topic in the investment literature has generated as much debate as the link between corporate tax policy and investment. While traditional theories of corporate investment predict that the long run impact of corporate tax changes on investment is -1 (Jorgenson, 1963; Hall and Jorgenson, 1967), the findings in the empirical literature remain contentious and inconclusive, even to date. Although a larger proportion of the literature finds evidence in support of the neoclassical benchmark, a growing number of studies cast doubt on the importance of corporate tax policy in investment promotion. Some studies (such

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as Chirinko, Fazzari and Meyer, 1999; Bond *et al.*, 2003) have found that the sensitivity of investment to corporate tax is much smaller than theoretically predicted. Others (such as Verbič and Črnigoj, 2014; Yagan, 2015; Črnigoj, 2016) do not find any evidence of the impact of corporate tax improvements on investment. The summary evidence on the responsiveness of investment to tax policy is therefore inconclusive.

Much of the empirical evidence has however come from more advanced economies, an observation also made by Bond and Xing (2015). The lack of evidence from developing country contexts is quite striking, given the well-known fact that since the 1990's most developing regions undertook wide-ranging tax reforms as part of the broader IMF and World Bank structural adjustment programmes. In South Africa, significant tax policy reforms have also been ongoing since the early 1990's. Yet only a tiny number of studies on corporate tax policy and investment exist in developing countries.

The lack of empirical evidence on corporate tax and investment in developing countries is largely due to the non-availability of firm-level datasets. Although government held tax-return records may exist in some countries, most tax databases are unreconciled and thus unusable for research. Moreover, harmonised datasets such as those available in South Africa at SARS do not stretch back far enough to the 1990s when corporate tax reforms were most frequent and significant. These peculiar issues have contributed to a lack of research on corporate taxation and investment, potentially resulting in poorly designed and ineffective corporate tax policies in developing countries.

Given the clear need for more empirical evidence, this study investigates the responsiveness of firm-level investment to corporate tax policy changes in South Africa. The study estimates a neoclassical investment model (Jorgenson, 1963; Hall and Jorgenson, 1967) using company financial statement data for non-financial firms listed on the Johannesburg Stock Exchange (JSE) over the period 1999 to 2012. This period is associated with some of the most notable changes in South Africa's corporate tax policy, aimed at reducing companies' marginal costs of capital to promote investment. The paper estimates an autoregressive distributed lag (ARDL) investment model using the Blundell and Bond (1998) GMM estimator which is robust to econometric problems such as dynamic panel bias, possible reverse causality between investment and tax policy, possible measurement error in the tax variable and firm fixed-effects.

Our findings suggest that despite the observed reductions in the tax-adjusted marginal costs, investment did not respond to corporate tax policy as predicted by traditional investment theories. The findings are similar to those from other developing countries (Črnigoj, 2016; World Bank, 2016). A plausible hypothesis for the null effect of corporate tax policy changes on investment could be the presence of financial constraints in the investment markets. As argued by Fazzari *et al.* (1988), firm investment may no longer respond to fundamentals such as the tax-adjusted marginal costs in the presence of imperfect capital conditions[1].

[1] This hypothesis appears plausible, given that other studies (such as Makina and Wale, 2016; Vengesai and Kwenda, 2018) have found evidence of the presence of financial constraints

This hypothesis appears plausible, given that other studies (such as Makina and Wale, 2016; Vengesai and Kwenda, 2018) have found evidence of the presence of financial constraints among firms in South Africa.

This empirical paper is organised as follows: the next section presents a review of both the theoretical and empirical literature and highlights the contributions that this paper makes. Section 3 discusses corporate tax reforms in South Africa since the late 1990s. That section discusses the key changes in corporate tax policy and the resulting evolution of the tax-adjusted user cost of capital over the study period. The data and methods are then discussed in section 4 while section 5 presents and discusses the results. The conclusion is presented in section 6.

2 Literature Review

The relevant theoretical framework for the study of the relationship between corporate tax and investment is presented in Jorgenson (1963), who provides the first neoclassical theory of investment based on the profit-maximisation behaviour of firms. The basic premise of the theory is that there exists an optimal capital stock for each firm; whereby investment (or divestment) is simply the process of reaching that optimum. Crucially, Jorgenson (1963) characterised an investment model in which investment is explicitly dependent on changes in demand and the rental price of capital or user cost of capital (UCC). In Jorgenson's (1963) theory, the role of corporate tax policy in investment necessarily works through its effects on the UCC, which in turn impacts firm-level investment.

Following the early success of the neoclassical theory (in applications such as Hall and Jorgenson, 1967; Eisner and Nadiri, 1968), Jorgenson (1963)'s theoretical framework has been the standard theoretical framework of investment since the 1960's. The neoclassical approach has however been criticised, particularly for its reduced-form characterisation of the investment adjustment process. Structural theories such as the Q (Tobin, 1969) and Euler models (Abel, 1980) whose structural equations are derived directly from a dynamic optimisation problem soon emerged as alternative theories. In the Q-theory, the adjustment process is characterised by market information, with a firm's expected life-cycle returns of capital captured by the ratio of market value of capital to its replacement costs. In the Euler equation theory, direct quadratic adjustment costs describe the adjustment process. Although not commonly found in the investment-corporate tax field, these structural equation models have been estimated in the broader investment literature. The Q model has been applied in studies such as Hayashi (1982), Hubbard (1998), Audretsch and Elston (2002) and Peters and Taylor (2017) while the Euler has been used in studies such as Federici and Parisi (2015) and Cevik and Miryugin (2018).

Although the structural theories have a better theoretical appeal over the reduced-form neoclassical investment model, their use in applied work has been criticised. The Q model has for example been criticised for serious problems

among firms in South Africa.

in the measurement of the q-ratio, and for having very limited applications in contexts outside the stock markets or in situations where financial frictions exit (Hayashi, 1982; Simmler, 2012). The Euler also suffers criticism for being too restrictive (Chirinko, Fazzari and Meyer, 1999; Dwenger, 2014), for imposing empirically implausible quadratic adjustment costs (Doms and Dunne, 1998) and for being too strict in the context of investments under irreversibility (Dixit and Pindyck, 1994). Moreover, the performance of structural equations in empirical applications has been quite disappointing (Oliner, Rudebusch and Sichel, 1995; Bond and Van Reenen, 2007).

To address some of the criticisms of the dominant structural models, contemporary views such as the financial constraints (Myers and Majluf, 1984; Fazzari et al, 1988) and institutional (North, 1991) theories emerged to explain firm investment. In particular, the financial constraints theory argues that in the presence of capital market imperfections, neoclassical fundamentals such as the tax-adjusted marginal cost of capital may fail to explain investment. In the presence of capital market imperfections, the availability of internal finance becomes an important determinant of firm-level investment. Several studies (such as Bond and Meghir,1994; Compello et al, 2010; Gezici et al (2018) lend support to the financial constraints hypothesis.

The institutional theory of investment on the other hand views investment as largely determined by the formal rules that structure economic interactions (North, 1991). According to North (1991), institutions create order, reduce uncertainty, affect the cost of production and exchange, and thus create the economic environment which determines whether firms invest or not. In clarifying the role of institutions, Dollar et al (2005) argue that the investment climate (defined as the institutional, policy, and regulatory environment) "is the link from sowing to reaping." Poor investment climates (such as inefficient bureaucracy, corruption and inadequate physical and financial infrastructure) would imply high uncertainty and transaction costs, resulting in poor incentives for investment in fixed assets (North, 1991; Dollar et al, 2005). Empirical studies such as Ayyagari et al (2008), Aiello et al (2012) and Ponticelli and Alencar (2016) find evidence in support of the importance of institutions and investment climate in firm-level investment.

Based on the above review of theory, this paper will use the Jorgenson (1963) and Hall and Jorgenson (1967) neoclassical investment theory as the framework is best suited to study the link between corporate tax policy and investment in South Africa. Notable studies such as Chirinko et. al 1999; Chirinko and Von Kalckreuth, 2003; Dwenger, 2014; and Buettner and Hoenig, 2016) have used this framework to investigate firm-level investment dynamics in advanced economies.

Empirical evidence on the link between corporate tax and investment is vast. Most studies have sought to establish whether the user cost of capital is indeed negative one (-1) as predicted by neoclassical theory (Jorgenson, 1963). The findings in the empirical literature are however far from convergence on the size of the user-cost of capital coefficient. Generally, studies that use industry or aggregate data have struggled to find a large user cost elasticity. Using

US manufacturing industry data, one of the earliest neoclassical applications (Eisner and Nadiri, 1968) found that the tax-adjusted user cost elasticity only ranged between 0 and -0.33, a range that is far below the theoretical prediction of -1. Subsequent studies based on industry data generally estimate relatively low user cost elasticity coefficients. For example, studies such as Auerbach and Hassett (1992), Smith (2008), and Bond and Xing (2015) have all reported user cost elasticities of around -0.4 or less.

Concerns about potential bias in the user-cost estimates in aggregate data have been highlighted in the literature. Chirinko et al (1999) and Goolsbee (2004) have argued that the tax effects found in studies based on aggregate data may be biased downwards, due to problems such as measurement error, firm heterogeneity, and simultaneity bias. Moreover, as further pointed out by Dwenger (2014), aggregate data may suffer limited variation in the parameters used in estimating the user cost of capital, thereby making identification of the user cost parameter difficult. For these reasons, recent studies have generally used more granular data such as firm-level records. Data at the firm level is also deemed well suited for the study of investment given that firms are the natural vehicle through which investment decisions are made. Moreover, firm-level datasets also allow researchers to better control for such econometric concerns as firm fixed effects and endogeneity due to dynamic panel bias among other problems (Chirinko, Fazzari and Meyer, 1999).

Despite the increased availability of micro-datasets, the question about the exact relationship between corporate tax policy and investment is far from consensus. While some early micro studies found evidence of a significant and negative relationship between the user cost of capital and investment, the size of the coefficient estimates were quite small. For example, despite controlling for aggregation bias, dynamic bias and other econometric problems, Chirinko et al (1999) only found a relatively small user cost elasticity of -0.25 using USA manufacturing sector firm data. Other early efforts in using micro-data in the 1990's yield results that are imprecise. For example, Cummins *et. al* (1994) found user-cost elasticity estimates ranging from -0.5 to -1 in their examination of firm-level investment patterns in the USA. Using plant-level investment data from the US manufacturing sector, Caballero et al (1995) found an even wider range of the long-run user cost elasticities (between -0.01 and -2).

Since the year 2000, there has been a steady increase in firm-level studies aimed at shedding light on the size of the user cost of capital. Some studies (such as Dwenger, 2014; Bond and Xing, 2015; Buettner and Hoenig, 2016) have found evidence of elasticity estimates of around -1, in line with neoclassical theory. However, other studies (such as Harhoff and Ramb, 2001b; Chatelain, 2003; Chirinko, Fazzari and Meyer, 2011; Črnigoj, 2016) have found user-cost estimates that are far below the predicted neoclassical benchmark. Moreover, it's not uncommon to find studies that find zero or null effects of corporate tax policy (see for example Chatelain, 2003; Črnigoj and Verbič, 2014; Yagan, 2015).

The empirical evidence on the impact of corporate tax on investment is highly concentrated in advanced economies, with very little evidence from developing regions. Studies that have focused on developing countries and regions are only a handful. For example, Črnigoj (2016) investigates the relationship between corporate tax reforms and investment in Slovenia but found no effect of corporate tax changes in investment. In a study involving Indonesia, Vietnam, Thailand, Malaysia and the Philippines, Cevik and Miryugin (2018) finds that moderate corporate tax reforms do not translate into improved investment in the ASEAN region. In South Africa, a recent study based on SARS tax records also finds insignificant effects of corporate tax policy on investment (World Bank, 2016).

The above empirical review has largely focused on studies that assess the responsiveness of investment to changes in the tax-adjusted user cost of capital using the approach in Chirinko et al (1999) and Dwenger (2014), where estimates of the user-cost elasticity are obtained by estimating a neoclassical investment model using dynamic panel techniques such as GMM estimation. While this has been the dominant strategy for estimating the investment effects of corporate tax policy under the Jorgensonian framework, recent papers have begun to use quasi-experimental approaches to estimate the direct effect of corporate tax policy changes on investment. In Germany, Dobbins and Jacob (2016) find that the 2008 corporate tax cuts led to a one-to-one increase in the investment of domestic firms. Following a similar quasi-experimental strategy as Dobbins and Jacob (2016), Ohrn (2018) found that the 2005 corporate tax expenditure programme in the USA led to a 4.7% increase in capital investment for each 1 percentage point reduction in corporate taxes for the beneficiary firms. Liu and Mao (2019) report that the introduction of permanent tax incentives for fixed capital investments over six years from 2004 -2009 in China led to a 38 percent increase in capital investment for the treated firms relative to the control group.

While the emerging evidence from the quasi-experimental strand of literature seems to suggest a generally significant impact of corporate tax policy changes on investment, Yagan (2015) however found that that corporate tax reforms of 2003 in the US did not stimulate capita investment, although the reforms evaluated in that study focused on corporate dividend tax cuts.

Based on the above literature review, this study contributes to the literature on the impact of corporate tax and investment in the following ways. First, by using data from a developing country such as South Africa, the study contributes rare evidence in a field overwhelmingly dominated by studies from the USA and Western Europe[2]. Specifically evaluating the interaction of corporate tax policy and investment in a developing country context such as South Africa would help other developing countries in formulating effective corporate tax policies. Second, by controlling for the effects of likely attrition bias in my findings, this study contributes new insight to the literature on corporate tax and investment. This is important given that the literature has largely ignored the possibility of attrition bias even though it's common for firms to drop out of samples over time.

[2] Although the World Bank supported a similar study in South Africa (World Bank, 2016), that study covered a shorter time frame with fewer episodes of corporate tax policy changes than this study.

3 Overview of corporate tax reforms and incentives in South Africa

Since the transition to democratic rule in 1994, South Africa's corporate tax policy has undergone significant reviews and reforms, resulting in a relatively efficient and competitive corporate tax system especially in comparison with other regional countries (Davis Tax Committee, 2018). The main objectives of these reforms were to stimulate investment and economic growth to address the persistent challenges of unemployment, poverty, and inequality in South Africa (Katz Commission, 1997; Davis Tax Committee, 2018). Some of the significant reforms include several episodes of reductions in the top marginal corporate tax rate from the end of apartheid in 1994 until 2012; and the introduction of the accelerated depreciation allowances especially in the manufacturing sectors in the early 2000s. These changes are reflected in the Income Tax Act 58 of 1962 (Republic of South Africa, 1962) as amended over the years. A specific goal of these reforms was to encourage capital investment in the various assets and sectors of the South African economy.

In addition to the reductions in the headline corporate tax rate since the democratic transition, several other reforms such as the reduction and eventual elimination of the secondary tax on companies (STC) have taken place. The STC was introduced in the income tax code in 1993 to encourage companies to re-invest part of their earnings and to mitigate the decline in tax revenues. As of 1996, the STC rate stood at 12.5% but was reduced to 10% in 2006 and finally abolished in 2012 to re-align the South African dividend tax structure with global norms and practice and to remove the perception of high and unfavourable company taxation regime in South Africa (South African Revenue Service, 2019). As a result, the STC was replaced by the dividend tax – a tax levied on dividends in the hands of the shareholders rather than at the company level. Given the changes in the headline and secondary corporate tax rates over the study period, the combined effective reduction in overall company taxation has reduced over time. Table 1 illustrates the trends in corporate tax reductions over the period 1999 to 2012.

Other notable investment incentives over the period include the introduction of accelerated depreciation allowances for new plant and machinery in the manufacturing sector at the rate of 40%, 20%, 20%, and 20% in the year 2002 (Republic of South Africa, 1962). The mining sector also saw the introduction of 100% depreciation expensing of new plant and machinery; while schemes that offered an accelerated depreciation schedule of 50%, 30%, 20% were also introduced in the agriculture and renewable energy sectors in the same year (Republic of South Africa, 1962). The South African income tax code also provides for the deductibility of interest expense and operating costs but does not allow for the deduction of dividends and capital expenditures. The deductibility of interest expense has further provided a general investment tax incentive for firms in South Africa.

In calculating the tax-adjusted user cost of capital in this paper, we take into account the variations in the main headline tax rate, the depreciation allowances, and interest deductibility of debt. While South Africa has many other tax and non-tax incentives that could be modeled in the user cost estimates, not all the relevant tax incentives can be considered in this study because the financial records used in the study do not contain such details. For instance, under the famous 12i Tax Allowance Investment incentive (12i TAI), companies could receive various cash grants, investment allowances, and learnership allowances for attaining specified investment levels and training criteria. These cash grants and investment allowances are not specifically reported in the financial statements of the companies listed on the JSE and are therefore not incorporated in calculating the user cost of capital used in this paper. To this extent, therefore, our estimate of the user cost of capital could be considered as a lower bound estimate for the real firm-level user costs of capital in cases where firms enjoy further incentives.

4 Data and Summary Statistics

4.1 Dataset

The main sources of data for this study are the balance sheets and income statements of non-financial companies listed on the South African Johannesburg Stock Exchange (JSE). The data was collected from Datastream - an online financial data subscription service provided by Thomson Reuters (Datastream, 2016). The use of the JSE data in this study has several advantages. First, while data on larger firms may under-represent the smaller ones, larger firms are more likely to be responsive to corporate tax changes because smaller firms are typically exempt from corporate tax payments and therefore only face limited exposure to corporate taxation. Second, the JSE firm panel used here is considerably longer than other currently available alternatives like the company tax returns data from the South African Revenue Service (SARS). Our JSE panel series captures some of the major reforms of the 1990s and early 2000s while in contrast, the SARS tax returns data recently used in similar studies such as World Bank (2016) rely on very limited variation in corporate tax policy changes. Third, we note that due to strict regulatory requirements for JSE listed companies such as having externally audited financial statements, the data in this study is arguably of better quality than other options.

The JSE dataset used in this study is therefore one of the best-suited options to study the relationship between investment and corporate tax policy over a period of actual corporate tax reforms in South Africa. Several other South African studies have used the JSE firm-level data to investigate various investment models (e.g., Ntim, 2013; Makina and Wale, 2016; Vengesai and Kwenda, 2018). Elsewhere, Quader and Taylor (2018) have used listed firm-level data sources from Datastream - the same source as our study - to estimate investment models for the UK. Kumar and Ranjani (2019) and Crisostomo et al (2013) also estimated investment models using firm-level financial data from

India's Bombay Stock Exchange and the Sao Paolo Stock Exchange in Brazil, respectively.

This study uses data from non-financial companies listed on the JSE over the period 1999 to 2012. The dataset excludes firms in the banking, insurance, real estate, general financial services, equity and non-equity investment, and health care sectors according to the FTSE/Dow Jones Industry Classification Benchmark (ICB) criteria used in Datastream. The number of firms before conducting any data cleaning and restricting our sample to the relevant panel and variables is 249 firms, representing 3,541 firm-year observations. Observations with missing data on the key variables such as investment, capital stocks, debt, sales, and the user-cost of capital were dropped. Four more observations with very high sales growth rates of over 100% and cash flow ratio above 10 were also dropped as such patterns are deemed highly unusual (Vengesai and Kwenda, 2018). In the final step, I follow the literature (Hovakimian and Titman, 2006; Quader and Taylor, 2018) and winsorize the relevant variables at 1% in both tails to minimise the impact of extreme values arising from any extra-ordinary shocks, large mergers and acquisitions, or severe measurement errors. Lastly, all firm observations with less than 5 years of consecutive runs are dropped from the data given that the dynamic specifications estimated in this study require a minimum of 5 consecutive observations.

After cleaning the data, the final sample comprised 196 firms operating in 7 different non-financial sectors of the South African economy. The final sample has a minimum of 5 and a maximum of 14 consecutive years of financial data, yielding a total of 2,129 firm year-observations. Table 2 shows the composition of the sample by industry.

Given the dynamic nature of the models estimated in the next sections, I also provide a sense of the distribution of the observations by the number of maximum spells (or continuous spells) of consecutive data in our sample. Table 3 presents those summary spells while Table 4 shows the distribution of observations by year.

Although firm panels generally have attrition, the likely impact of attrition bias has often been neglected in this specific literature on corporate tax and investment. Quader and Tayor (2018) have for example argued that unbalanced firm panels are expected to be free from any potential selection effects and survivor bias in panels that allow for the free entry and exit of firms. Based on similar assumptions, various studies such as Buettner and Hoenig (2016), World Bank (2016), Vengesai and Kwenda (2018) and Quader and Taylor (2018) assume away the risk of attrition bias. However, as pointed out by Dwenger (2009; 2014), the reasons for attrition such as cessation of business or mergers, bankruptcy, or falling below listing requirements could be correlated with the decision to invest, and therefore likely to cause attrition bias. However, despite the potential of significant attrition bias in unbalanced panels, very little attention has been paid to address this problem. Following Dwenger (2009) and Wooldridge (2002), I test for the likely effects of attrition bias in some specifications of the econometric models in this paper.

Next, we consider the summary statistics of the key variables required to estimate the investment equations adopted in this paper. The variables are defined according to the standard literature and discussed below.

4.2 User cost of capital and other variables

The impact of corporate taxation on investment is traditionally analysed using the tax-adjusted user cost of capital in the tradition of the Jorgenson (1963), and Hall and Jorgenson (1967) neoclassical investment framework. Under neoclassical investment theory and assuming perfect capital markets, the user cost of capital is the channel through which corporate taxes affect investment. The user cost of capital is defined as the minimum return a firm needs on a marginal investment to cover depreciation, taxes, and the opportunity cost of investing in capital (Dwenger, 2009; Liu, 2011). Thus, the user cost is comprehensive, taking into account the investment effects of not only tax policy (e.g. statutory tax rates, depreciation and investment allowances etc) but also the macro-economic factors that impact investment such as inflation and interest rates.

Unlike the “backward-looking” average tax measures based on proportions of tax expenses to profits that have been used previously in the literature (for example Mutti and Grubert, 2004; Desai, Foley and Hines, 2007), Egger et al. (2009) argues that the “forward-looking” user cost of capital is robust to endogeneity in the context of investment models. The user cost of capital is therefore considered the theoretically sound basis for analysing neoclassical investment behaviour (Egger *et al.*, 2009; Nguyen-Thanh and Strupat, 2013).

This paper follows the user cost of capital formulation by Chartelain et al (2003) which is based on Auerbach et. al (1983)’s model. The model uses the weighted average definition of the user cost of capital where the costs of debt and equity are weighted by their respective shares in total liabilities of the firm. Typically, company financial statements tend to aggregate fixed assets into broader categories, making it difficult to apply user cost models such as the King and Fullerton (1984) model. The user cost formulation used in this study has been applied in other studies such as Mojon, Smets and Vermeulen, 2002; Chatelain *et al.*, 2003; Karim and Azman-Saini, 2013; Shokr, Abdul Karim and Zaidi, 2017) that use financial statement data. Following Chartelain et al (2003), the user cost of capital based on company financial statement data can be represented as:

$$UC_{it} = \frac{P^I_{st}}{P_{st}} \frac{(1 - {}_t z_s)}{(1 - {}_t)} \left[AI_{it} \frac{D_{it}}{D_{it} + E_{it}} (1 - {}_t) + (LD_t) \left(\frac{E_{it}}{D_{it} + E_{it}} \right) - (1 - {}_s) \frac{\Delta P^I_{st+1}}{P^I_{st}} + {}_s \right] \tag{1}$$

Where p^I_{st} and p_{st} are the price of capital goods and final goods (respectively) in sector s at time t. The implicit price series for machinery equipment is used as a proxy for the price of capital goods while the consumer price index is the proxy for the price of final goods. The corporate tax rate is represented by τ. z is the present value of depreciation allowances and is estimated using the approach in World Bank (2015) and industry-level data from Statistics South Africa. AI is the interest rate and is measured using the short-term prime overdraft rate from the South African Reserve Bank. LD is the long-term debt rate and proxies for the opportunity cost of equity and is measured using the 10-year government bond rate from the South African Reserve Bank. The book values of equity, E and debt, D come from financial statement data from Datastream (2016). The industry specific rate of economic, δ_s, is estimated from industry level financial statement data from Statistics South Africa following the approach in World Bank (2015).

The other relevant variables are defined according to the literature. Firm-specific investment ($I_{i,t}$) is calculated as capital expenditure normalized by the previous year's net capital stock ($K_{i,t-1}$). Sales ($S_{i,t}$) is calculated by deflating the nominal sales in the financial statement using the CPI and is used as a proxy for output. The variable definitions used in this paper are listed in Table A1 in the appendix. Table 5 presents the summary statistics for the key variables used in the investment regression models.

Based on Table 5, we first note that the firm-level data are right-skewed as expected. This is reflective of the presence of very large firms on the JSE and therefore justifies the use of capital ratios or logs to scale the model variables as suggested by Chirinko et al (1999). The summary statistics show that the average level of investment for a typical firm, as indicated by the investment-capital ratio ($I_{i,t}/K_{i,t-1}$), is about 34% of net fixed assets. The results are within the range of estimates found in studies such as Crnigoj (2016) and World Bank (2016) who reported net investment rates of 27% and 38% for Slovenia and South Africa, respectively. The average growth rate in real sales was about 13%. A related South African study (World Bank, 2016) however found a higher mean sales growth rate of about 23% using the SARS tax returns data. However, the median growth rates between our study (6.3%) and the World Bank (2016) study (8.3%) are comparable. The mean user cost of capital on the other hand increased by about 6% although the median user cost declined by about 5.2%. While the mean increase may indicate the influence of outliers or influence of the price component of the user cost, the reduction for the median firm reflects the impact of the corporate tax incentives for a typical firm over time. The pattern of movements observed above is similar to what Dwenger (2014) and Crnigoj (2016) have also reported in Germany and Slovenia, respectively.

To gain a sense of the relationship between investment and changes in UCC, Figure 1 presents the correlation between movements in capital stock and the user cost. The graph shows that gradual reductions in the user cost of capital are broadly correlated with increases in capital stock in various industries over time, although the correlations are not particularly strong.

5 Theoretical Model and Empirical Specification

Based on the review of theory, this study uses the neoclassical empirical framework (Jorgenson, 1963; Hall and Jorgenson, 1967; Eisner and Nadiri, 1968) in conceptualising the relationship between corporate tax and investment. Following Eisner and Nadiri (1968), Chirinko, Fazzari and Meyer (1999) and Dwenger (2014), the production function for a firm i at time t can be parameterised with constant elasticity of substitution technology as:

$$F\left(K_{i,t}, L_{i,t}\right) \equiv S_{i,t} = \gamma_t \left[\eta_i K_{i,t}^{-\rho} + \left(1-\eta_i\right) L_{i,t}^{-\rho}\right]^{-\frac{\nu}{\rho}} \tag{2}$$

where $\rho = \left(\frac{1}{\sigma}\right) - 1$, ν represents the degree of the function. η_i and $(1-\eta_i)$ are the firm-specific relative factor shares of capital K and labour L (respectively). γ_t is the year-specific production technology. Taking the first-order conditions and equalising the marginal productivity of capital and marginal cost yields the following equation of optimal capital stock $K_{i,t}^{*}$:

$$K_{i,t}^{*} = A_i T_t S_{i,t}^{\beta} UCC_{i,t}^{-\sigma} \tag{3}$$

were $\beta = \sigma + \frac{1-\sigma}{v}$. The optimal level of capital is a function of output (or sales $S_{i,t}$), a firm-specific distribution parameter A_i , technology T_t as well as the user cost of capital $UCC_{i,t}$. The parameter of interest is the long-term elasticity of capital stock with respect to the $UCC_{i,t}$, given by $-\sigma$. In a world without frictions and adjustment costs, a firm's current capital stock instantaneously equals the optimal capital level. Thus, the optimal capital stock can be stated as a log-linear function of the log of current sales $S_{i,t}$, the log of current user cost of capital $UCC_{i,t}$, a firm-specific effect a_i and a deterministic time trend d_t that captures technological progress.

However, in the presence of adjustment costs, firms do not immediately adjust to their optimal targets. To capture the costs of adjustment and uncertainty, the neoclassical approach models capital stock as dependent on its lagged values, as well as both the current and lagged values of sales and user cost of capital (Chirinko, Fazzari and Meyer, 1999). Adding the stochastic error term $\varepsilon_{i,t}$ yields the following equation of current capital stock:

$$k_{i,t} = c + a_i + \sum_{h=1}^{H} {}_h k_{i,t-h} + \sum_{h=0}^{H} \beta_h s_{i,t-h} - \sum_{h=0}^{H} \sigma_h ucc_{i,t-h} + \sum_{t=1}^{T-1} \tau d_t + \varepsilon_{i,t} \tag{4}$$

The prevailing estimating model proposed byChirinko et al., (1999) and applied in subsequent studies assumes that investment typically comprises replacement and net components, with replacement capital being proportional to the beginning of period capital. Net capital is defined as the change in stock scaled by the beginning of period capital stock:

$$\Delta k_{i,t} = \frac{I_{i,t}}{K_{i,t-1}} - \delta_i \tag{5}$$

Given that firm-level data typically exhibit large differences in size and are right-skewed, Chirinko et al., (1999) propose specifying the equation for capital in ratios. Thus, the estimating equation can be presented in the following autoregressive distributed lag form:

$$\frac{I_{i,t}}{K_{i,t-1}} = \delta_i + \sum_{h=1}^{H} {}_h \frac{I_{i,t}}{K_{i,t-h-1}} + \sum_{h=0}^{H} \beta_h \Delta s_{i,t-h} - \sum_{h=0}^{H} \sigma_h \Delta ucc_{i,t-h} + \Delta\varepsilon_{i,t} \quad (6)$$

Equation (6) is the prevailing estimating equation that the literature uses, and this study also adopts this specification with one investment lag and three lags on output and user cost of capital. This specification enables comparison with findings from the broader ARDL based literature (such as Chirinko, Fazzari and Meyer, 1999; Dwenger, 2009; Simmler, 2012; Črnigoj, 2016).

Estimating this model using standard OLS would yield biased and inconsistent estimates due to the likely presence of endogeneity from various sources. As shown by Goolsbee (2000), OLS is considerably biased towards zero due to measurement error in the UCC. Given that this paper uses price aggregates at the national and not firm-level, measurement error is likely present. There is also a possibility of the presence of simultaneity bias between investment and the UCC variable as investment shocks may affect investment which would, in turn, impact interest rates and the UCC (Chirinko, Fazzari and Meyer, 1999; Goolsbee, 2004). Investment may also be contemporaneously determined with output (Dwenger, 2009). These issues in the context of the dynamic nature of the investment equation suggest the use of an instrumental variable estimator.

Although one may make a simplifying assumption of "no unobserved individual effect" and estimate the investment equation using OLS as done by Lang et al (1996), such an assumption would be overly simplistic and likely lead to biased estimates in the context of firm-level data. Using the fixed effects estimator would help address the failure of OLS to control for individual effects, however, the estimator would still not adequately address the endogeneity in the context of dynamic models. Nickell (1977) argues that with fixed effects, the mean error term would still be correlated with the mean of the lagged dependent variable even when the sample size increases indefinitely.

Although a possible solution to the Nickell bias is the Anderson-Hsiao (1982) (A-H) estimator which reduces dynamic bias by using first differencing, the A-H estimator does not take into account all the available moment conditions and is relatively inefficient. To obtain more efficient estimates, this paper uses GMM estimators that exploit all available moment conditions thereby solving the problem of weak instruments and yielding more efficient results. In particular, we adopt the system GMM estimator by Blundell and Bond (1998) over the difference GMM estimator (Arellano and Bond, 1991) as the former uses more moment conditions and shown to be more efficient than the latter (Roodman, 2009a). However, given the well-known fact that GMM is not foolproof and could be sensitive to specification, our estimates are subjected to various GMM specification checks such as changing the instrument sets and varying the length of the instruments. The next section presents and discusses the findings of this paper.

6 Results and discussion

6.1 Main findings

Table 6 presents the results of estimating the baseline investment model specified in Equation (6). The first column presents results from the OLS model, while the last two columns present results estimated using the system GMM estimator (by Blundell and Bond, 1998). The OLS results are used as a benchmark, to enable comparison with estimates obtained using the more consistent GMM estimator given the problem of endogenous regressors and dynamic panel bias that OLS fails to address.

Turning to the variable of interest, the results in Table 6 suggest that there is no substantive impact of changes in the tax-adjusted user cost of capital on investments. Although the user cost of capital coefficients have the desired direction (-0.16 to -0.09), the estimates are not statistically significant across the models estimated[3]. The estimates under OLS are potentially biased due to the likely presence of endogeneity and dynamic panel bias as discussed. Controlling for these econometric problems using GMM yields relatively smaller UCC coefficient estimates compared to OLS. This is suggestive of bias correction due to GMM although the results remain insignificant[4]. Overall, the consistency and precision in UCC coefficient estimates across both OLS and GMM re-affirms our finding that corporate tax policy has no impact on investment, at least in our sample. Various factors such as the dampening effect of the 2008/9 financial crisis, and the limited variation in the UCC variable could explain the insignificant effect of changes in UCC on investment. These and other issues are interrogated further in section 2.6.2.

Our results suggest that contrary to expectation, changes in corporate tax do not affect firm-level capital investment in South Africa. While this finding contradicts the neo-classical prediction of a user cost of capital coefficient of -1, our findings not the only exception. Other studies (such as Chirinko et al., 1999; Harhaff and Ramb, 2001; Verbič and Črnigoj, 2014; and Yagan, 2015) also find evidence that contradicts the neo-classical theoretical prediction of a user cost coefficient of negative one. More specifically, this study joins Verbič and Črnigoj (2014), Črnigoj (2016), World Bank (2016) as well as Yagan (2015) who found a zero effect of corporate tax policy changes on investment. Specifically, Verbič and Črnigoj (2014), and Črnigoj (2016) found no impact of corporate tax changes on investment in Slovenia while a recent study by the World Bank (2016) shows that corporate tax policy does not impact manufacturing firms' capital investment in South Africa.

The impact of sales or output on capital formation is however found to be positive and significant as expected. In particular, for every 10% increase in out-

[3]Across all models in Table 6, the wald tests reject the null hypothesis that UCC coefficient is equal to -1 and fail to reject the null of zero coefficients (p-value = 0.000 across all models). These tests confirm that UCC is indeed statistically insignificant.

[4]The findings of an insignificant effects of UCC on investment persist even when the length of the instrument lags is varied from 2 -5 (Column 2) to 2-7 years (Column 3) as shown in Appendices A2 and A3.

put, capital investment rises by between 5 - 6%. The results are quite precisely estimated across all the specifications and fall within the range of coefficient estimates found in studies that have used the ARDL and DL specifications (see for example Chirinko et al., 1999; Dwenger, 2009; 2014; and Simmler, 2012).

Before discussing the implications of the findings in this paper, it is important to review the adequacy of the estimated model and validity of estimation techniques and instruments used. First, is the baseline model in Equation (6) indeed a dynamic series? To answer this, we focus on the coefficients of the lagged investment variable in the first row of Table 6. As can be seen, the investment lag is significant and persistent in all the specifications. In particular, the results indicate that past investment explains about 24% to 30% of current investment. The coefficient sizes of the lagged investment variable are also consistent with the notion of dynamic stability (Bond, 2002) in all the specifications. Taken together, these results suggest that specifying the baseline investment model as a dynamic or autoregressive is reasonable and allays any concerns of biasedness due to model misspecification.

Next, we consider a few diagnostic tests, given that dynamic GMM estimators are only consistent and efficient in the absence of serial correlation in the transformed error terms and when instruments are valid. Arellano and Bond (1991) and Blundell and Bond (1998) suggest running the Sargan-Hansen tests of over-identifying restrictions to check for the validity of the instruments; and running the Arellano-Bond test to check for second-order serial correlation in the transformed lag. These diagnostic tests are inbuild in the xtabond2 Stata module (Roodman, 2009, 2015) and reported in all the dynamic estimations in this study. As can be seen in Table 6, the AR (2) test (with the p-values at 0.626 and 0.745, respectively) fails to reject the null hypothesis of no second-order serial correlation. The Sargan-Hansen test (with the p-values of 0.318 and 0.270, respectively) also fails to reject the null hypothesis that the instruments are valid. These diagnostic tests suggest that the estimated dynamic GMM specifications are reliable.

Furthermore, it is well known that dynamic GMM estimations can be sensitive to changes in specification, especially if the underlying model is misspecified. To check the stability of the baseline results in Table 6, I follow the suggestions in Roodman (2009) and re-run the estimations by varying specifications such as the length of the instrument lags, using different instruments, and changing estimation procedures (two-and one-step; and comparing the system-versus difference-GMM estimations). The results remain largely stable. The finding that tax policy does not impact capital investments is consistent, as the user cost of capital coefficient remains insignificant in all the alternative models specified. In addition, the alternative specifications confirm the persistence of lagged investment and impact of output on investment in all the specifications. The results of the above alternative specifications are presented in Tables A2, A3 and A4 in the appendix.

6.2 Robustness checks

The results presented so far may be sensitive to factors such as attrition, the effects of the 2008/2009 financial crisis, and even potential measurement error in the user cost of capital. To assess whether the results remain stable after controlling for some of the likely biases, a few checks are performed. First, given that this study uses an unbalanced panel, attrition may be a problem if firms leave the sample in a non-random way. Unobservable factors that affect attrition may also be correlated with the decision and level of investment. Not accounting for attrition in the investment equations may therefore lead to endogenous estimates. Surprisingly, despite the risk of potentially endogenous estimates, most studies in this specific investment-tax literature do not account for the potential bias due to non-random attrition. A quick review of about a dozen relevant studies that focus on the nexus between investment and user cost indicates that only Dwenger (2009;2014) has discussed and tested for the likely impacts of attrition the estimations[5]. All the other studies beginning with the seminal paper by Chirinko et al (1999) appear largely pre-occupied with only estimating the user cost coefficient. The issue of attrition appears quite distant, even amongst other notable studies such as Bond *et al.*, (2003), Almeida and Campello (2007) and Baum *et al.,* (2011) that have focussed on the financial (as opposed to the neoclassical) determinants of investment.

One justification for overlooking the dynamics of exit may be found in Quader and Taylor (2018), who argue that allowing for the entry and exit of firms over time potentially "frees" the sample from any selection effects and survivor bias. Although this argument may hold, it is nevertheless prudent to test for the presence and likely bias due to attrition whenever possible. This study implements a three-step attrition test procedure outlined in Wooldridge (2002) and applied by Dwenger (2014). In the first step, the probability of dropping out of the sample is predicted based on predictors such as the profit margin, changes in real sales, and firm size as proxied by total assets. I then calculate the inverse mills ratio (IMR) in the second step and finally include the IMR in estimating the main investment equation. To obtain consistent standard errors, the standard errors are bootstrapped. The results of estimating the main investment model controlling for attrition bias are contained in the Appendices in Table A6 (Panel A).

Secondly, selection bias due to the entry of new firms may be a concern. New entrants may be typically structurally different from established surviving firms. Moreover, new entrants would not have prior-period records, thereby posing difficulties especially on the measurement of variables with lags. In the case of listed firms, however, firms may exist long before they are listed and could thus be operationally similar to existing firms in some respects at the time of listing. Due to the absence of information on the nature of entries, I cannot directly control for new entrants. Nonetheless, to see whether the full sample estimates are likely influenced by new entries, I compare the full sample results with the estimates from a sub-sample of survivor firms only. Those results are

[5] Table A5 in the appendix shows a list of the relevant studies reviewed.

reported in the Appendices in Table A6 (panel B).

The test for attrition reveals an insignificant inverse mills ratio. This suggests that non-random attrition is not an issue in this dataset. The estimates in this study are therefore not biased by the presence of attrition in the data. These findings are in line with Dwenger (2009; 2014) who found that attrition did not bias results in a similar study in Germany. The results in Table A6 also indicate no differences between the full sample and restricted regression for survivor firms, suggesting that my estimates are not significantly influenced by the entry of new firms on the stock exchange.

Next, I consider the likelihood that the null effect of tax policy on investment in this study may simply be due to the impact of the 2008/2009 financial crisis. Given that my sample spans the period 1999-2012, there is a possibility that the observed unresponsiveness of investment to corporate tax changes may simply be due to the investment dampening effect of the 2008/2009 financial crisis. To investigate this possibility, I re-estimate the base model in Equation (6) for the period 1999-2008 just before the full impact of the crisis materialised. If the full sample (1999-2012) estimates were simply a reflection of the dampening effects of the financial crisis, I expect that the pre-crisis sample estimation to yield a significant tax coefficient if corporate tax reforms influenced capital investment. Table A7 in the Appendix shows the results of this estimation.

As can be seen in Table A7, our estimates of the investment model before the 2008/2009 financial crisis show that South African corporate firms did not increase their investments in response to changes in corporate tax reforms. These findings suggest that the corporate tax is simply not the channel through which investment accumulates in South Africa.

Lastly, I consider the possibility that the null effects found in this paper may simply be due to measurement error in the user cost of capital estimate used here. As shown by Goolsbee (2004), measurement error could bias the user cost of capital towards zero. Given that several components of the user cost of capital in Equation (1) are only available at the industry or national level, measurement error could be an issue in this study. For instance, I used aggregate producer prices of machinery equipment and the aggregate CPI as proxies for the firm-specific investment goods price and firm-specific output prices as required in Equation (1). To rule out the possibility that the effect of the user cost of capital could be annulled by the influence of the industry aggregates, I re-estimate the baseline model purely focusing on the tax components of the UCC specified as $\tau\tau$[6] $(1 - {}_t z_s) \,/\, (1 - {}_t)$. The results reported in Table A8 in the appendix do not dispute the overall conclusion that corporate tax policy does not influence investment in South Africa.

[6] Bond and Xing (2015) similarly restrict their UCC specification to the tax component. This specification however lacks within firm variation in the user cost.

7 Discussion

Our finding that investment does not significantly respond to tax incentives in the neoclassical framework is similar to other studies in Slovenia (Črnigoj, 2016) and South Africa (World Bank, 2016). More generally, the findings belong to a broader category of studies that have questioned the importance of corporate tax policy in investment determination (Fazzari *et al.*, 1988; Chirinko, Fazzari and Meyer, 1999; Harhoff and Ramb, 2001a; Yagan, 2015). The insignificant impact of corporate tax on investment may however simply be due to the presence of financial constraints in the South African economy. As argued by Fazzari et al (1988), in presence of liquidity constraints, investment may no longer respond to neoclassical fundamentals such corporate tax but to the availability of internal finance. Given recent evidence of the presence of significant financial constraints among South African firms (Makina and Wale, 2016; Vengesai and Kwenda, 2018), it is therefore plausible that the presence of financial constraints in the South African economy may dampen the role of corporate tax policy in stimulating investment in South Africa.

Other plausible factors may explain the null effect of corporate tax policy on investment. In particular, not all the tax incentives have been modelled in this study. As already discussed, some incentives under the Department of Trade and Industry's 12i Tax Allowance Incentive could not be incorporated in the UCC computation due to a lack of data. To the extent that such incentives cause significant reductions in marginal taxes, their positive effects are not captured in this study. Furthermore, there is a possibility that the non-response of investment to corporate tax policy could simply be due to the practice of profit-shifting by JSE companies with links to multinational corporations. Using South African tax data, Wier and Reynolds (2018) recently found suggestive evidence of tax-shifting of profits to low-tax jurisdictions by large South African corporations. To the extent that profit shifting is significant and perverse, corporate tax incentives may not result in capital investment in South Africa but may instead subsidise investment and profit generation in other jurisdictions.

Finally, the finding that higher output increases firm-level capital investment is interesting and important for policy. Policies that support household disposable income and aggregate spending such as social grants, inadvertently play a crucial role in sustaining firm-level capital investment and growth. More directly, the findings imply that South Africa export diversification and growth initiatives such as the Integrated National Export Strategy are likely to not only spur export growth but also lead to the much-needed firm-level capital investment in South Africa.

8 Conclusion

This paper considered the impact of corporate tax changes on capital investment among South African firms. The study used balance sheet and financial statement data of non-financial companies listed on the Johannesburg stock exchange. The study exploited rare variations in the marginal statutory tax rates and capital depreciation allowance provisions to estimate the user cost of capital elasticity. We found that while the changes in corporate tax policy successfully lowered the marginal cost of investment, the reductions did not translate into significant increases in firm-level capital investments. These findings suggest that capital investment policy in South Africa must look beyond corporate tax policy. Focusing reform efforts on improving efficiency and liquidity in the financial markets could help firms lower their marginal costs and expand investments.

Our finding that higher sales (or output) significantly impact firm-level capital investment is important for policy. In particular, increasing household income and aggregate spending by maintaining the current momentum in the roll-out of social cash transfer programmes would support firm-level investment and growth in South Africa. More directly, the finding implies that South Africa's ongoing export diversification and growth initiatives such as the Integrated National Export Strategy are likely to lead to gains in firm-level capital investment and should be enhanced.

In conclusion, this paper calls for more studies that explore the responsiveness of investment to all the available corporate tax incentives including those directly and preferentially administered by the South African Department of Trade and Industry. Future studies could also explore the extent to which the illegal practice of profit shifting negates the effects of corporate tax incentives on investment formation in South Africa. In addition, future studies could investigate the direct role of investment risk factors such as unstable electricity supply, labour and industrial conflict, crime, and corruption on firm-level capital investment in South Africa.

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Table 1: Corporate Tax Rates (1998-2012)

	Corporate income tax	Secondary tax on companies	Effective statutory tax rate*
1998	35%	13%	37.41%
1999	30%	13%	32.59%
2000	30%	13%	32.59%
2001	30%	13%	32.59%
2002	30%	13%	32.59%
2003	30%	13%	32.59%
2004	30%	13%	32.59%
2005	29%	13%	31.63%
2006	29%	13%	31.63%
2007	29%	13%	31.63%
2008	28%	10%	30.18%
2009	28%	10%	30.18%
2010	28%	10%	30.18%
2011	28%	10%	30.18%
2012	28%	0%	28%

*The effective rate is calculated assuming a one third dividend pay-out.
Source: South African tax laws

Table 2: Sample by Industry Sectors

Industry	No. of obs	%	No. of firms	%
Oil & Gas	9	0.42	1	0.51
Basic Materials	465	21.84	43	21.94
Industrials	720	33.82	71	36.22
Consumer goods	256	12.02	22	11.22
Consumer services	403	18.93	33	16.84
Telecoms	49	2.3	6	3.06
Technology	227	10.66	20	10.2
Total	2,129	100	196	100

Source: Datastream (2016) company database and own calculations, 1999-2012

Table 3: Sample by continuous data spells

Max. spells	No. of obs	%	No. of firms	%
5	100	4.7	15	7.65
6	126	5.92	20	10.2
7	112	5.26	16	8.16
8	160	7.52	19	9.69
9	81	3.8	9	4.59
10	90	4.23	9	4.59
11	55	2.58	5	2.55
12	132	6.2	11	5.61
13	195	9.16	15	7.65
14	1078	50.63	77	39.29
Total	2,129	100	196	100

Source: Datastream (2016) company database and own calculations, 1999-2012

Table 4: Sample distribution by year

Year	Obs	%
1999	92	4.32
2000	107	5.03
2001	120	5.64
2002	127	5.97
2003	133	6.25
2004	141	6.62
2005	154	7.23
2006	164	7.7
2007	177	8.31
2008	191	8.97
2009	185	8.69
2010	183	8.6
2011	181	8.5
2012	174	8.17
Total	2129	100

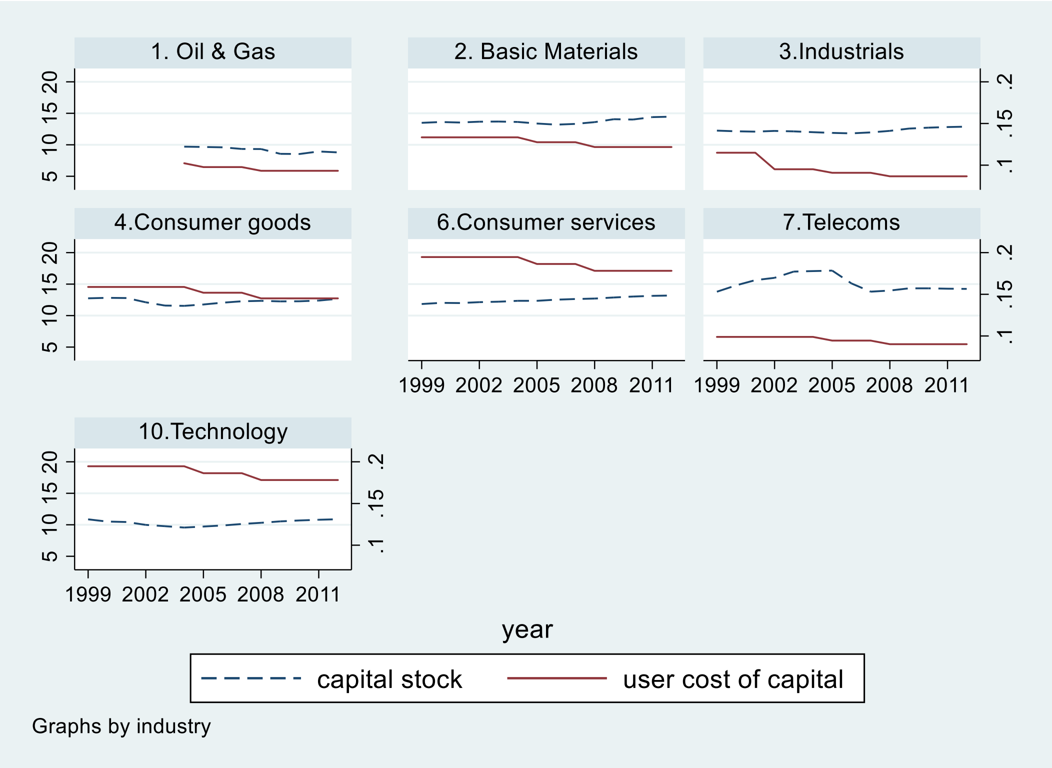
Source: Datastream (2016) company database and own calculations, 1999-2012

Table 5: Descriptive statistics of the key variables

Variable	Mean	Median	Std.Dev	Min	Max
$K_{i,t}$ (R'mil)	3 340	292	9 367	0	72 800
$I_{i,t}/K_{i,t-1}$	0.338	0.227	0.454	0	4.766
$S_{i,t}$ (R'mil)	8 848	1 881	17 000	0	120 000
$\Delta.S_{i,t}/S_{i,t-1}$	0.132	0.063	0.757	-1.000	28.076
$UCC_{i,t}$	0.190	0.196	0.059	-0.074	0.284
$\Delta.UCC_{i,t}/UCC_{i,t-1}$	0.060	-0.052	0.453	-2.051	2.685

Source: Datastream (2016) company database and own calculations, 1999-2012.

Figure 1: Changes in capital and user cost over time, by industry (1999-2012)



Notes: The graph shows changes in mean log of capital and log of user cost of capital by industry, using the UCC definition based on the tax components only.
Source: Datastream (2016) company database and own calculations, 1999-2021.

Table 6: Estimates of user cost of capital and sales

$I_{i,t}/K_{i,t-1}$	OLS (1)	GMM (2)	GMM (3)
$I_{i,t-1}/K_{i,t-2}$	0.253***	0.297***	0.239***
	(0.055)	(0.063)	(0.064)
$\Delta ucc_{i,t}$			
σ_0	0.007	0.016	0.022
	(0.048)	(0.042)	(0.043)
σ_1	-0.063***	-0.039	-0.044*
	(0.023)	(0.027)	(0.024)
σ_2	-0.063**	-0.040*	-0.046**
	(0.024)	(0.023)	(0.021)
σ_3	-0.037	-0.024	-0.025
	(0.022)	(0.022)	(0.021)
SUM(σ)	**-0.156***	**-0.087**	**-0.093**
	(0.088)	(0.090)	(0.076)
$\Delta\beta_{i,t}$			
β_0	0.336***	0.458**	0.464**
	(0.115)	(0.204)	(0.199)
β_1	0.161***	0.119**	0.149***
	(0.048)	(0.051)	(0.046)
β_2	0.016	-0.006	0.004
	(0.052)	(0.060)	(0.062)
β_3	-0.007	-0.033	-0.043
	(0.043)	(0.060)	(0.066)
SUM(β)	**0.506*****	**0.539*****	**0.574*****
	(0.139)	(0.209)	(0.228)
Observations	1,083	1,083	1,083
No. of firms	174	174	174
No. of instruments	-	124	161
AR(1) (p-value)		0.011	0.012
AR(2) (p-value)		0.626	0.745
Sargan-Hansen (p-value)		0.318	0.270

Notes:
Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). *S*UM(σ) and *S*UM(*β*) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. Column (1) is estimated using pooled OLS with cluster-robust standard errors. Columns (2) and (3) are estimated using the system GMM estimator with robust standard errors. The instruments for the estimated equations are the lags of the regressors. All regressions include industry-year effects.
Source: Datastream (2016) company database and own calculations, 1999-2012.

Appendices

Table A1. Datastream variables

Variable	Description	Code
Investment	CAPITAL EXPENDITURES represent the funds used to acquire fixed assets other than those associated with acquisitions. It includes but is not restricted to: Additions to property, plant and equipment and Investments in machinery and equipment.	WC04601
Capital stock	PROPERTY, PLANT AND EQUIPMENT (NET) represents Gross Property, Plant and Equipment less accumulated reserves for depreciation, depletion and amortization.	WC02501
Sales	NET SALES OR REVENUES represent gross sales and other operating revenue less discounts, returns and allowances. It includes but is not restricted to: Franchise sales when corresponding costs are available and included in expenses. Consulting fees	WC01001
Income before extra-ordinary items	NET INCOME BEFORE EXTRAORDINARY ITEMS/PREFERRED DIVIDENDS represents income before extraordinary items and preferred and common dividends, but after operating and non-operating income and expense, reserves, income taxes, minority interest and equity in earnings.	WC01551
Depreciation expense	DEPRECIATION represents the process of allocating the cost of a depreciable asset to the accounting periods covered during its expected useful life to a business. It is a non-cash charge for use and obsolescence of an asset.	WC01148
Cash flow	Inc before extra-ordinary items (WC01551) + depreciation expense (WC01148) divided by beginning of period capital stock (WC0250)	(WC01551+ WC01148)/ WC0250
Total assets	TOTAL ASSETS represent the sum of total current assets, long term receivables, investment in unconsolidated subsidiaries, other investments, net property plant and equipment and other assets.	WC02999
Long term debt	LONG TERM DEBT represents all interest-bearing financial obligations, excluding amounts due within one year. It is shown net of premium or discount	WC03251
Long term leverage	Long term debt (WC03251) / Total assets (WC02999)	WC03251 WC02999
Employees	EMPLOYEES represent the number of both full and part time employees of the company. *It excludes: Seasonal employees, Emergency employees*	WC07011
Dividends	CASH DIVIDENDS PAID - TOTAL represent the total common and preferred dividends paid to shareholders of the company. *It excludes: Dividends paid to minority shareholders.*	WC04551
Earnings before interest and tax (EBIT)	EARNINGS BEFORE INTEREST AND TAXES (EBIT) represent the earnings of a company before interest expense and income taxes. It is calculated by taking the pre-tax income and adding back interest expense on debt and subtracting interest capitalized.	WC18191

Source: Thomson Financial (2007)

Table A1. Datastream variables (continued)

Variable	Datastream description	Code
Market capitalisation	Market Price-Year End * Common Shares Outstanding *If Common Shares Outstanding is not available for the current year or prior year, then Common Shares Outstanding-Current is used*	WC08001

Source: Thomson Financial (2007)

Table A2: Sensitivity of GMM estimates to varying instrument lag specifications

VARIABLES	(1) 2-4 lags	(2) 2-6 lags	(3) All lags	(4) 3-5 lags
$I_{i,t-1}/K_{i,t-2}$	0.306***	0.245***	0.242***	0.179
	(0.078)	(0.068)	(0.052)	(0.118)
$\Delta ucc_{i,t}$				
σ_0	0.014	0.019	0.023	0.025
	(0.036)	(0.042)	(0.044)	(0.037)
σ_1	-0.034	-0.037	-0.049*	-0.033
	(0.028)	(0.025)	(0.025)	(0.026)
σ_2	-0.029	-0.036*	-0.051**	-0.026
	(0.019)	(0.021)	(0.022)	(0.020)
σ_3	-0.021	-0.022	-0.026	-0.007
	(0.019)	(0.021)	(0.021)	(0.020)
SUM(σ)	**-0.070**	**-0.076**	**-0.102**	**-0.041**
	(0.077)	**(0.082)**	**(0.081)**	**(0.80)**
$\Delta\beta_{i,t}$				
β_0	0.459***	0.479**	0.426**	0.445**
	(0.158)	(0.214)	(0.164)	(0.197)
β_1	0.102**	0.140***	0.153***	0.349***
	(0.046)	(0.050)	(0.048)	(0.106)
β_2	-0.010	0.012	0.000	0.029
	(0.057)	(0.063)	(0.061)	(0.053)
β_3	-0.048	-0.037	-0.046	-0.021
	(0.052)	(0.059)	(0.055)	(0.046)
SUM(β)	**0.503*** **	**0.593*** *	**0.533*** **	**0.802*** **
	(0.178)	**(0.229)**	**(0.184)**	**(0.248)**
Observations	1,083	1,083	1,083	1,083
No. of firms	174	174	174	174
No. of instruments	101	144	201	100
AR(1) p-value	0.012	0.011	0.012	0.029
AR(2) p-value	0.606	0.723	0.740	0.973
Sargan-Hansen (p-value)	0.438	0.372	0.911	0.560

Notes:

Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). SUM(σ) and SUM(β) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. The instruments for the estimated equations are the lags of the regressors lagged as indicated in the column headings above. All regressions are estimated using the system GMM estimator (Blundell and Bond, 1998) and include industry-year effects.

Source: Datastream (2016) company database and own calculations, 1999-2012.

Table A3: Sensitivity of GMM estimates to different instrument sets

VARIABLES	(1) 2-5 lags	(2) 2-7 lags	(3) 2-5 lags	(4) 2-7 lags
$I_{i,t-1}/K_{i,t-2}$	0.205***	0.207***	0.278***	0.272***
	(0.072)	(0.069)	(0.049)	(0.055)
$\Delta ucc_{i,t}$				
σ_0	0.050	0.049	0.029	0.036
	(0.040)	(0.043)	(0.033)	(0.035)
σ_1	-0.037	-0.049*	-0.044**	-0.048**
	(0.026)	(0.027)	(0.022)	(0.024)
σ_2	-0.030	-0.044**	-0.016	-0.029*
	(0.021)	(0.021)	(0.020)	(0.017)
σ_3	-0.008	-0.017	-0.013	-0.016
	(0.021)	(0.020)	(0.020)	(0.017)
SUM(σ)	**-0.025**	**-0.061**	**-0.043**	**-0.057**
	(0.085)	**(0.081)**	**(0.074)**	**(0.071)**
$\Delta s_{i,t}$				
β_0	0.453**	0.456**	0.396***	0.404**
	(0.181)	(0.189)	(0.142)	(0.194)
β_1	0.120**	0.132***	0.096*	0.098*
	(0.052)	(0.050)	(0.054)	(0.056)
β_2	0.028	0.026	0.034	0.034
	(0.050)	(0.053)	(0.046)	(0.043)
β_3	-0.033	-0.033	-0.025	-0.028
	(0.062)	(0.061)	(0.049)	(0.050)
SUM(β)	**0.567*** **	**0.581*** **	**0.501*** **	**0.507*** **
	(0.194)	**(0.210)**	**(0.160)**	**(0.186)**
Observations	1,083	1,083	1,083	1,083
No. of firms	174	174	174	174
No. of instruments	122	155	83	105
AR(1) p-value	0.013	0.013	0.009	0.010
AR(2) p-value	0.786	0.796	0.636	0.646
Sargan-Hansen (p-value)	0.505	0.371	0.749	0.610

Notes:
Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). SUM(σ) and SUM(β) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. The instruments for the first-differenced regressions are the values of estimated equations are the values in levels of the first-differenced lags of $\Delta ucc_{i,t}$ .and $\Delta ucc_{i,t}$ (as specified in Dwenger, 2014). The regressions in columns (1) and (2) allow the lag of investment ($I_{i,t-1}/K_{i,t-2}$) to enter as the instrument set in levels starting at the second lag. Columns(3) and (4) exclude the investment lag from the instrument set. All regressions are estimated using the system GMM estimator (Blundell and Bond, 1998) and include sets of time dummies.
Source: Datastream (2016) company database and own calculations, 1999-2012.

Table A4: Comparison of estimation by one-or two-step GMM estimation procedures

VARIABLES	(1) 1-step Sys (lags 2-5)	(2) 1-step Sys (lags 2-7)	(3) 1 step Diff (lags 2-5)	(4) 2-step Diff (lags 2-5)
$I_{i,t-1}/K_{i,t-2}$	0.275***	0.235***	0.157**	0.160**
	(0.064)	(0.059)	(0.063)	(0.062)
$\Delta ucc_{i,t}$				
σ_0	0.021	0.025	0.090	0.092**
	(0.044)	(0.043)	(0.076)	(0.044)
σ_1	-0.048*	-0.045	-0.025	-0.022
	(0.028)	(0.028)	(0.038)	(0.021)
σ_2	-0.049**	-0.048**	-0.008	0.017
	(0.021)	(0.022)	(0.035)	(0.025)
σ_3	-0.030	-0.025	0.009	0.035
	(0.022)	(0.021)	(0.049)	(0.028)
SUM(σ)	**-0.105**	**-0.093**	**0.066**	**0.122**
	(0.081)	**(0.081)**	**(0.145)**	**(0.091)**
$\Delta s_{i,t}$				
β_0	0.462**	0.469**	0.585***	0.525***
	(0.198)	(0.190)	(0.215)	(0.185)
β_1	0.132***	0.149***	0.147**	0.161***
	(0.050)	(0.048)	(0.062)	(0.050)
β_2	-0.013	0.002	-0.004	0.029
	(0.061)	(0.061)	(0.066)	(0.055)
β_3	-0.045	-0.045	-0.048	-0.018
	(0.062)	(0.059)	(0.082)	(0.063)
SUM(β)	**0.537****	**0.574*****	**0.680****	**0.700*****
	(0.221)	**(0.214)**	**(0.280)**	**(0.235)**
Observations	1,083	1,083	907	907
No. of firms	174	174	157	157
No. of instruments	124	161	95	95
AR(1) p-value	0.011	0.011	0.005	0.014
AR(2) p-value	0.681	0.751	0.981	0.926
Sargan-Hansen (p-value)	0.318	0.270	0.782	0.782

Notes:
Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). SUM(σ) and SUM(β) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. The instruments for the first-differenced regressions are the values of the lagged regressors. The regressions in columns (1) and (2) are estimated using the one-step system GMM while Columns (3) and (4) are estimated using the one-and two-step difference GMM procedure (respectively). All regressions include industry-time effects.
Source: Datastream (2016) company database and own calculations, 1999-2012.

Table A5: Consideration for attrition bias in the Investment-Corporate tax literature

Relevant study	Country/Regional focus	Is attrition mentioned/discussed?	Is attrition bias corrected for?
Cevik and Miryugin (2018)	Indonesia, Malaysia, Philippines, Thailand Vietnam	Not mentioned	No
World Bank (2016)	South Africa	Not mentioned	No
Crnigoj (2016)	Slovenia	Not mentioned	No
Buettner and Hoenig (2016)	Germany	Not mentioned	No
Federici and Parisi (2015)	Italy	Not mentioned	No
Dwenger (2014)	Germany	Discussed	Yes
Karim (2012)	Malaysia	Not mentioned	No
Simmler (2012)	Germany	Not mentioned	No
Dwenger (2009)	Germany	Discussed	Yes
Gilchirst and Egon (2007)	USA	Not mentioned	No
Chatelain et al (2003)	Germany, France, Italy, Spain, Austria, Belgium, Luxenbourg	Not mentioned	No
Harhoff and Ramb (2001)	Germany	Not mentioned	No
Chirinko et. al (1999)	USA	Not mentioned	No

Table A6: Attrition; and Exclusion of new entrants

	Attrition Bias		Survivor	
	(1)	(2)	(3)	(4)
	2-5 lags	2-7 lags	2-2 lags	2-4 lags
$I_{i,t-1}/K_{i,t-2}$	0.283***	0.241***	0.235	0.295**
	(0.081)	(0.086)	(0.170)	(0.121)
$\Delta ucc_{i,t}$				
σ_0	-0.003	0.014	0.040	0.041
	(0.058)	(0.053)	(0.039)	(0.030)
σ_1	-0.035	-0.043	-0.036**	-0.030*
	(0.029)	(0.028)	(0.017)	(0.016)
σ_2	-0.043	-0.046*	-0.005	-0.006
	(0.029)	(0.027)	(0.015)	(0.013)
σ_3	-0.035	-0.030	0.013	0.011
	(0.032)	(0.029)	(0.018)	(0.014)
SUM(σ)	**-0.115**	**-0.106**	**0.011**	**0.016**
	(0.120)	**(0.111)**	**(0.072)**	**(0.059)**
$\Delta s_{i,t}$				
β_0	0.471**	0.476**	0.249***	0.231***
	(0.212)	(0.204)	(0.077)	(0.066)
β_1	0.122**	0.148***	0.081**	0.092***
	(0.054)	(0.053)	(0.032)	(0.029)
β_2	-0.008	0.004	0.162*	0.050
	(0.062)	(0.067)	(0.088)	(0.044)
β_3	-0.034	-0.039	0.062	0.032
	(0.065)	(0.060)	(0.107)	(0.033)
SUM(β)	**1.056****	**1.106*****	**0.554*****	**0.405*****
	(0.431)	**(0.417)**	**(0.207)**	**(0.102)**
IMR	0.014	-0.005	-	-
	(0.039)	(0.031)	-	-
Observations	1,077	1,077	679	679
No. of firms	174	174	77	77
No. of instruments	124	161	53	101
AR(1) p-value	0.011	0.011	0.007	0.007
AR(2) p-value	0.646	0.732	0.858	0.852
Sargan-Hansen (p-value)	0.225	0.371	0.513	0.949

Notes:
Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). *S*UM(σ) and *S*UM(*β*) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. The instruments for the first-differenced regressions are the values of the lagged regressors. All estimates done by two-step system GMM. All regresions include industry-time effects.
Source: Datastream (2016) company database and own calculations, 1999-2012.

Table A7: Pre-financial crisis impact (1999-2008)

VARIABLES	(1)	(2)
$I_{i,t-1}/K_{i,t-2}$	0.407***	0.316**
	(0.115)	(0.143)
$\Delta ucc_{i,t}$		
σ_0	0.040	0.048
	(0.035)	(0.046)
σ_1	-0.020	-0.010
	(0.029)	(0.037)
σ_2	-0.003	-0.002
	(0.026)	(0.037)
σ_3	0.009	0.014
	(0.026)	(0.037)
SUM(σ)	**0.026**	**0.049**
	(0.099)	**(0.134)**
$\Delta s_{i,t}$		
β_0	0.514	0.655
	(0.329)	(0.428)
β_1	0.055	0.068
	(0.101)	(0.108)
β_2	-0.010	-0.015
	(0.051)	(0.064)
β_3	-0.056	-0.073
	(0.067)	(0.098)
SUM(β)	**0.502***	**0.636***
	(0.272)	**(0.365)**
Observations	652	652
No. of firms	136	136
No. of instruments	79	98
AR(1) p-value	0.007	0.007
AR(2) p-value	0.958	0.799
Sargan-Hansen (p-value)	0671	0.530

Notes:
Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). SUM(σ) and SUM(β) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. The instruments for the first-differenced regressions are the values of the lagged regressors. All regressions estimated using the two-step system GMM. All regresions include industry-time effects.
Source: Datastream (2016) company database and own calculations, 1999-2012.

Table A8: alternative specifications of UCC

VARIABLES	(1)	(2)
$I_{i,t-1}/K_{i,t-2}$	0.415***	0.321***
	(0.087)	(0.068)
$\Delta ucc_{i,t}$		
σ_0	-0.089	-0.199
	(1.371)	(1.437)
σ_1	-0.502	-0.857
	(1.576)	(1.659)
σ_2	-0.926	-1.674
	(1.540)	(1.628)
σ_3	-1.036	-2.004
	(1.412)	(1.465)
SUM(σ)	**-2.554**	**-4.735**
	(4.467)	**(4.372)**
$\Delta s_{i,t}$		
β_0	0.409***	0.448***
	(0.144)	(0.148)
β_1	0.063*	0.105***
	(0.038)	(0.038)
β_2	-0.021	-0.011
	(0.040)	(0.043)
β_3	-0.025	-0.015
	(0.045)	(0.048)
SUM(β)	**0.427***	**0.527***
	(0.137)	**(0.146)**
Observations	1,295	1,295
No. of firms	189	189
No. of instruments	114	157
AR(1) p-value	0.006	0.006
AR(2) p-value	0.478	0.605
Sargan-Hansen (p-value)	0.478	0.405

Notes:
Dependant variable: Investment, scaled by the replacement cost of the beginning of period capital stock ($I_{i,t}/K_{i,t-1}$). SUM(σ) and SUM(β) denote the long run coefficient of the user cost of capital and output respectively, calculated as described in the text. Standard errors in parentheses. Significance levels are denoted as: *** p<0.01, ** p<0.05, * p<0.1. The instruments for the first-differenced regressions are the values of the lagged regressors. All regressions estimated using the two-step system GMM. All regressions include industry-time effects
Source: Datastream (2016) company database and own calculations, 1999-2012.